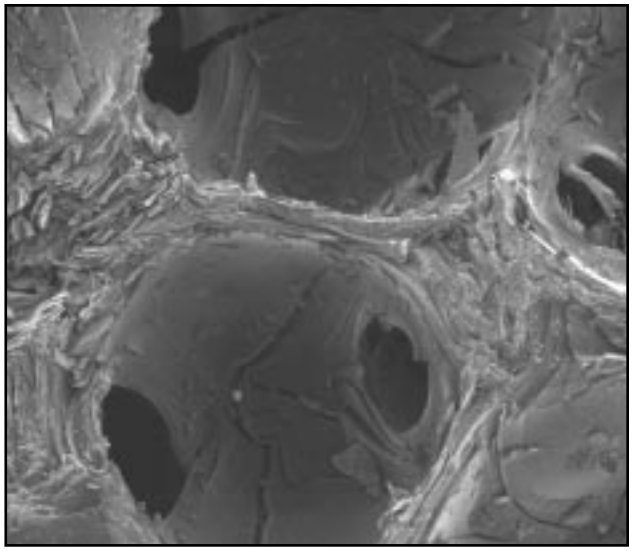
Taking the heat off electronics in electric and hybrid vehicles

OAAT ACCOMPLISHMENTS

Carbon Foams for Thermal Management

Challenge

Electric vehicles (battery powered) and hybrid electric vehicles (powered by both battery and internal combustion engine) rely on high-power electronics that create significant amounts of heat in operation. Mounted below the circuitry of most of these electronic assemblies is a water-cooled aluminum- or copper-core system that is complex, large, expensive, and requires power from the vehicle's engine to operate.



New carbon foam has excellent heat transfer characteristics.

Technology Description

A new carbon foam was developed with excellent heat transfer characteristics – five times the conductivity of copper and four times that of aluminum – that can be formed into a porous medium with an open cellular structure. This medium can be brazed to copper and aluminum elements without losing its thermal properties. The brazed configuration thus forms a passive cooling device that is an effective alternative to larger, more complex, and expensive water-cooled systems.

Accomplishments

The thermal conductivity of the carbon foam was increased by 50% to 150 W/mK, which compares favorably to water-cooled systems.

The carbon foam properties are compatible with the adverse environment that high-power electronics face inside vehicles. The foam withstands temperatures as high as 3,000° C, which is well above normal operating conditions.

Carbon foam also exhibits compressive strengths comparable to Kevlar®, making it durable enough to withstand even the harshest vehicle environments.

Benefits

The improved performance of carbon foam heat exchangers reduces the size, weight, and cost of the high-power electronics cooling system.

A carbon foam cooling system may operate passively and not require any engine power.

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Commercialization

A company, Poco Graphite, Inc., licensed the graphite foam technology to manufacture heat transfer products for a wide range of applications, including heat exchangers, heat sinks, and cooling systems for the chemical, glass, ceramic, aerospace, and medical industries.

PocoFoam™ prototype radiators, designed and built for Poco Graphite by Performance Research of Denver, North Carolina, were displayed at the Motorsports Engineering Conference and Exhibition in November 2000.

Award

2000 R&D 100 Award (to both Oak Ridge National Laboratory and Pcoo Graphite, Inc.)

Future Activities

The fabrication process for the carbon foam will be optimized to control the following properties:

- thermal conductivity
- heat transfer coefficient
- electrical conductivity
- strength
- brittleness
- pore size
- permeability

These properties will be matched to the needs of high-power electronic systems in automotive and other applications.

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